VIII. OSTEOLOGY OF OXYDACTYLUS.

A New Genus of Camels from the Loup Fork of Nebraska, with Descriptions of Two New Species.

By O. A. Peterson.

The material upon which the present paper is based, was collected by the writer during the season of 1901 from the upper Loup Fork sediment near the source of the Niobrara River, locally known as the Running Water, in Sioux County, Nebraska. After a careful study of this material the present writer is of the opinion that a new genus and at least two new species are represented.

Oxydactylus longipes, gen. et sp. nov.

The type (No. 918)[1] of this new genus and species consists of the skull, lower jaws, complete cervical region, five dorsals, and a few ribs, four lumbars, the sacrum and pelvis, the right scapula, proximal end of the ulna and radius, the unciform, magnum, and second row of phalanges, the right femur and distal end of the left femur, both tibiæ and the hind feet practically complete. I have selected as the cotype a second skeleton (No. 886) which pertains to a somewhat smaller individual, but evidently belonging to the same species. It was found in the same geological horizon and at the same locality and consists of the following material: Skull, lower jaws, atlas, axis, four lumbars, sacrum, and pelvis. Excepting the scapula the fore and hind limbs are well represented.

In addition to these two skeletons, which supplement one another in an admirable manner, there were found, in the same locality, a number of other skulls associated with more or less skeletal material and pertaining to the same species. In the following detailed description of the osteology of *Oxydactylus longipes* this supplementary material will be used whenever it throws additional light on the subject, but in all such instances references will be made to the catalogue numbers of the various parts referred to.

[1] Nos. refer to the Catalogue of the Section of Paleontology in the Carnegie Museum.

GENERIC CHARACTERS.

Dentition. — $I\frac{3}{3}$ $C\frac{1}{1}$ $P\frac{4}{4}$ $M\frac{3}{3}$.

Teeth brachyodont, superior incisors little reduced. No reduction in the premolars. The first upper molar narrower than the second, which is the broadest in the molar-premolar series. Third cervical vertebra the longest in the neck: the sixth with undivided inferior lamellæ. Limbs greatly elongated and slender. Trapezium present. Metacarpals entirely separated. Metatarsals separated with the exception of the palmar processes which are coössified. Phalanges without the plantar rugosities for pads which are present in the recent camels and llamas. Unguals high, narrow and pointed.

SPECIFIC CHARACTERS.

Cranium comparatively small. Third superior incisor as large as the canine. The first superior premolar two-rooted. Molars long and narrow. A short diastema between the third inferior incisor and the canine. The fifth metatarsal present and articulating proximally with the fourth by a distinct facet. Distally it is coössified with the fourth. The axis much shorter than the third cervical.

Superior Dentition. — In the type specimen (No. 918) (Pl. IV, Figs. 1, 2 and 3), the first and second incisors have dropped out, but the alveoles are open; they are each separated by a short diastema. A specimen (No. 667) in the collection, which is referred to the same species as the type, has the incisor teeth in position. These present characters similar to those of *Poëbrotherium*. They are small, subcylindrical in cross-section, with slightly expanded crowns covered by enamel. They show distinct wear in old individuals. This third incisor is present in the type and is a large caniniform tooth equaling the canine in size and similar to it in character. There is a long diastema between the third incisor and the canine; the latter, is situated just back of the maxillo-premaxillary suture and is a strong and slightly recurved tooth. The first premolar is separated by long diastemata from the canine and the second premolar. It is more obtuse in the present genus than in *Poëbrotherium*. Its greatest diameter is antero-posterior, and it is two-rooted. The second premolar is but little reduced and is very similar to that of *Poëbrotherium*. The median cusp is closely fused with the anterior and posterior cusps forming a sharp antero-posterior ridge of which the median cusp forms the summit. The second premolar is slightly shorter antero-posteriorly

than the third and fourth and is fixed by two strong roots. Pm. $\frac{3}{}$ is very similar to pm. $\frac{2}{}$, but has a much stronger internal basal cingulum and has a deep, narrow median valley, which is subject to considerable variation in different individuals. Pm. $\frac{4}{}$ differs from the others by having the internal crescent complete, and the anterior and posterior depressions of the external surface not so deep as in pm. $\frac{2}{}$ and $\frac{3}{}$. On the antero-external face of pm. $\frac{4}{}$ there is a prominent rib resembling the corresponding rib on pm. $\frac{4}{}$ in the recent camel and llama.

In *O. longipes* premolars $\frac{1}{}$, $\frac{3}{}$ and $\frac{4}{}$ *have undergone no reduction in size and little modification in form and resemble those of Poëbrotherium and Protomeryx.*[2]

The molars are brachyodont and closely resemble those of *Protomeryx*. The first is nearly one third longer antero-posteriorly than pm. $\frac{4}{}$. The succeeding teeth increase rapidly in length, the last molar being the longest by 2 or 3 mm. In width, the first molar differs from that in the recent camel and the llama. The latter genera, especially the llama, have the first molar the widest with a gradual decrease to the posterior portion of the last molar. In *Oxydactylus* the second molar is the widest while the first is the narrowest in the molar series. The ridges on the external face of the molars are quite prominent especially on the last tooth. This character is subject to individual variation. On molar $\frac{2}{}$ there are no basal pillars such as are found in the recent camel. The molar teeth in the present species are narrow and long, differing in this respect from another species of *Oxydactylus* which will be described later in this paper.

Inferior Dentition. — (Pl. IV, Fig. 4.) The similarity of the superior incisors to those of *Poëbrotherium* is repeated in the inferior series. Taken as a whole, the inferior incisors are rather small in comparison with those of the llama, the median pair being the smallest. The incisors are placed nearly as close together as they are in recent genera, and are well adapted for cropping grass. As stated above, the superior incisors are separated by short spaces; they are comparatively small and seem ill adapted for their required function in feeding. It would seem that there were cartilaginous pads on the premaxillaries which assisted to some extent at least in this operation. The canine is very unlike that of *Poëbrotherium*. The latter has the canine greatly compressed laterally, the antero-posterior diameter be-

[2] *Memoirs Am. Mus. Nat. Hist.*, Vol. I, Part VII, p. 422, 1901.

ing the greater, and the crown lance-shaped; while the canine in *Oxydactylus longipes* is a strong, slightly recurved, and perfectly caniniform tooth. This latter character seems already to have been present in *Protomeryx* the successor of *Poëbrotherium*. There is in *O. longipes* a short diastema in front and a long one back of the canine. The first premolar is strongly two-rooted, somewhat compressed laterally and has a simple subconical crown. The tooth is comparatively as strong as is that in *Protomeryx*. In *Oxydactylus*, as in all other genera known from the Oligocene and the Loup Fork, the first premolar is separated by diastemata from the canine and the second premolar. The second and third premolars are trenchant, laterally compressed, and are very similar to one another in character. The third has a more distinct anterior basal cusp and a small pit on the triturating face near the posterior edge. The fourth premolar has the antero-internal cusp less developed than in *Poëbrotherium*. This tooth is widest posteriorly, the internal ridge extending backward from the apex of the median cusp, thus forming with the external wall a shallow valley. This tooth on one side of the jaw differs from that on the other, as described above, in having the apex of the median cusp interrupted by two strong ridges, extending well down on the internal face of the tooth. The posterior valley is also less apparent. There is a gradual increase in length antero-posteriorly from pm. $\frac{1}{1}$ the shortest to m. $\frac{3}{3}$ which is the longest tooth in the mandible.

The inferior molars like the superior are long and narrow, and have a general resemblance to the molars in the recent camel and the llama, with the important exception that the basal pillars are entirely absent in *O. longipes*. The fifth crescent of the third molar varies in size in different individuals as has been observed in other genera of this family.

The Cranium.—The exceptionally well preserved skull and lower jaws of the type (No. 918), Pl. IV, Figs. 1, 2 and 3, deserve a rather complete and detailed description.

For the most part the sutures are distinguishable and the skull is otherwise quite complete. The extreme posterior part of the sagittal crest and the superior region of the supra-occipitals were missing when collected.

The cranium is comparatively small, elongate, and narrow. The facial region is especially long. The orbit is small in comparison with that of the llama and more ovate in shape, the greatest diameter

being the antero-posterior. It is placed nearly as far back as in the llama, and is closed behind by a bony bridge as in the latter genus. The inclosing of the orbit seems to have been completely accomplished in the genus *Protomeryx* while in *Poëbrotherium* the orbit is still open.[3] The skull has the upper contour somewhat similar to that of the recent camel, especially the frontals and parietals.

The sagittal crest is low, but well defined, and is nearly in line with the frontals, as in *Procamelus occidentalis*.[4] Slight crushing has taken place in the posterior region of the skull in the type, which in Pl. IV, Fig. 1 gives a slightly more depressed appearance to the supra-occip ital region, than would otherwise be the case. There are cavities below the nasals and above premolars $\frac{3}{}$ and $\frac{4}{}$. These cavities seem quite a constant feature among the known Loup Fork Camelidæ. The zygomatic arch is slender and the malar process deeply notched to receive the corresponding wedge-shaped process of the squamosal. In the antero-superior region of the orbit there is a deep notch similar to that in *Poëbrotherium*. This notch is also present in the recent genera, though not so deep. The crano-facial axis is straight. The occipital condyles seem to be subject to some variation ; in some cases they are rather high and narrow, while in others they are rounded, similar to those of *Poëbrotherium*. In the type the condyles are high and narrow ; inferiorly they are separated by a groove which extends across the accessory facets on the basi-occipitals, as in the camel and the llama. In *Poëbrotherium* this groove is entirely wanting, as is also the accessory surface for the inferior arch of the atlas. The supra-occipitals in *O. longipes* are high with prominent lambdoidal crests. The parietals are comparatively long, thus forming a longer, but somewhat narrower, brain case, than is seen in the llama, and more like that of the camel. In *Oxydactylus* the sagittal crest is thin and much higher than in the recent genera, and also differs from the latter in its almost rectangular contact with the elevated inion. In the camel the superior part of the supra-occipitals forms a broad and rather flat triangular surface where they meet the sagittal crest, which is low and short. In general appearance this region of the cranium of *O. longipes* more closely resembles that of the camel than the llama.

The zygomatic process of the squamosal is short in comparison with that of the camel and the llama, but as in the latter genera, is tapered

[3] *Bull. Am. Mus. Nat. Hist.*, Vol. X, pp. 114, 115, 1898.

[4] "U. S. Geogr. S.," Vol. IV, Part 2, Plate LXXVII, 1877, Lieut. G. M. Wheeler.

off to a thin point, which is received into the deep notch of the jugal. The glenoid cavity is a broad flat plate of bone with great antero-posterior extension, as in the recent camel. In the latter the articulation for the condyle of the mandible is continuous with the glenoid process at its internal margin, while externally the surface is interrupted by a broad shallow groove. This character is repeated in *O. longipes*, but the glenoid process is very much less developed in the latter genus. In the llama the glenoid cavity is much shorter antero-posteriorly and is entirely separated from the glenoid process by the broad shallow groove referred to above. The postorbital process of the jugal meets the corresponding process of the frontal, completely enclosing the orbit posteriorly. Anteriorly the jugal appears to extend farther than does that of the llama and the rugosity for the attachment of the masseter muscle is more prominent than in the recent genera.

The lachrymal sutures are discernible along the junction with the maxillary and this bone extends proportionally as far down on the face as in the llama. The large *vacuity* characteristic of the Tylopoda is situated immediately above the lachrymal.

The frontals resemble those of *Poëbrotherium* and are somewhat shorter than they are in the llama. Their widest diameter is above the orbits. Posteriorly, they are V-shaped and are received into a corresponding deep notch of the parietals. The supra-orbital ridges are well marked and terminate in the downward projecting supra-orbital processes. Anteriorly the frontals extend no farther down on the face than they do in *Poëbrotherium*. The fronto-nasal sutures present a W-shaped character, sharper than that which is found in the llama.

The nasals are long and narrow splints of bone overlapping the premaxillaries. As is well shown in Pl. IV, Fig. 2, the posterior process of each nasal is lance-shaped with blunt processes laterally and joins the maxillary close to the facial vacuity, from which point the suture extends anteriorly in a gently curved line constantly decreasing the width of the nasals which are only 15 mm. wide at the anterior end. On the whole, the nasals are proportionally shorter in *O. longipes* than they are in *Poëbrotherium*, but much longer than in the llama.

The paroccipital processes are very close to the occipital condyles and are long, broad, and placed obliquely to the long axis of the skull. The auditory bullæ are filled with cancellous tissue and are relatively smaller than in *Poëbrotherium*. Their position is somewhat

oblique to the long axis of the cranium and they do not crowd the basi-sphenoid as in *Poëbrotherium*. The bullæ are separated from the paroccipital processes by a heavy, rounded ridge extending as low down as the rest of this entire region with the exception of the paroccipital processes. The pit for the stylo-hyal is comparatively smaller than in the recent genera, and, like that of the llama, is deep and distinctly separated from the styloid groove. On the anterior apex of the bulla there is a sharp conical process somewhat similar to that seen in the camel. The external auditory meatus is as large as that of the llama and has nearly the same relative position. The tympanic region in *O. longipes* resembles that of the llama more clearly than that of the recent camel.

The pterygoids are comparatively narrow and are not expanded posteriorly as in the recent forms, especially the llama, but the hamular processes are nearly as well developed as in the Tylopoda in general.

The anterior extent of the palatines can not be ascertained in the type specimen. The pterygoids are moderately long and heavier than in the llama, ending in the hamular processes already mentioned. The posterior nares are long and narrow with the anterior border V-shaped and extending as far as the posterior border of the third molar. The palatine fissure between the posterior apex of the alveolar border of the maxillary and the pterygoids is very shallow. In the llama the posterior nares, the palatine foramen and the palatine fissure are subject to so much individual variation in position, and in some instances also in shape, that they are of little value for purposes of classification. Posteriorly the delicate vomer is broken away in all the specimens at hand, but the rapidly tapering presphenoid would indicate that the vomer has a posterior extension similar to that of the recent forms.

As in *Poëbrotherium* and *Protomeryx* the maxillaries are long and low. In front of the jugo-maxillary suture there begins a long heavy ridge which extends well in front of the deep depression on the upper part of the maxillary situated above premolars $\frac{3}{3}$ and $\frac{4}{4}$. This ridge is entirely obsolete in the recent forms and in these this surface presents a more regularly rounded appearance. In *O. longipes* as well as in other Loup Fork forms the anterior part of the maxillary expands rapidly to meet the posterior margin of the premaxillary. Thus the facial region is constricted behind the premaxillaries. Owing to the much more elongated muzzle of *Poëbrotherium* the corresponding ex-

pansion of the maxillaries is more gradual in that genus. In *O. longipes* as well as in other Loup Fork forms the anterior part of the maxillary expands rapidly to meet the posterior margin of the premaxillary. Thus the facial region is constricted behind the premaxillaries. Owing to the much more elongated muzzle of *Poëbrotherium* the corresponding expansion of the maxillaries is more gradual in that genus. In *O. longipes* the palatine plates of the maxillaries are proportionally shallower than they are in the recent forms, and, as in the latter, they extend well in front of the canines.

The premaxillaries are comparatively heavy especially at the supero-anterior margin, and they are expanded laterally as much as they are in the llama, forming an ovate and oblique narial opening. In *Poëbrotherium* the superior portion of the premaxillary is much broader than that of *O. longipes*, which again is much broader than in the recent genera. In *Poëbrotherium* the premaxillaries are in contact with the nasals throughout one third the length of the latter, as is the case also in *O. longipes*. In the recent genera there is an anterior process of the maxillaries, which, together with a shortening of the nasals, has reduced the contact of the latter elements with the premaxillaries. The palatine plates and the alveolar border of the premaxillaries are heavy to accommodate the superior incisors. The anterior palatine foramen is opposite the third incisor. In a number of different individuals of the family Camelidæ, both recent and extinct, which have been examined, the position of the anterior palatine foramen seems to be subject to considerable variation. Sometimes they are anterior to the lateral incisors, again directly opposite, while they will often be found nearly posterior to that tooth.

The Foramina. — The supra-orbital canal, as in *Poëbrotherium*, is placed well forward on the frontal and as in the recent camel it is near the median line. In the llama the position of these foramina is more lateral and also more posterior. The infra-orbital foramen is above the anterior part of molar $\frac{1}{1}$ practically in the same position as in recent genera, except that in *O. longipes* the foramen is closer to the alveolar border. The lachrymal foramen is single and situated within the orbit as in the llama. The anterior palatine foramen is opposite incisor $\frac{3}{3}$, and the posterior is situated anterior to pm. $\frac{4}{4}$. The optic foramen occupies the same relative position as in the llama; that is, immediately anterior to the large opening formed by the confluent foramen rotundum and lacerum anterius. The foramen ovale, as in

the llama, is separated from the lacerum medium only by a long thin bridge. The carotid canal is separated from the posterior lacerated foramen as in the llama and differs in this respect from that of the recent camel where the two canals have a common exit. The condylar foramen is located well back under the anterior edge of the accessory facet and is not visible from a direct palatine view of the skull. The postglenoid foramen is situated posterior to the glenoid process and is in appearance very similar to that of the recent camel. On the superior wall, at the base of the zygomatic process of the squamosal there is a perforation somewhat smaller than the corresponding foramen in the llama, and, as in the recent camel, it is situated in advance of the postglenoid foramen. There is a deep depression and a foramen superior to the exoccipitals similar to the foramens found in this region in recent forms. In a direct back view the foramen magnum appears somewhat triangular. Its superior border is slightly emarginated, the lateral borders being almost vertical, while the inferior border is V-shaped and terminates in the groove which separates the accessory facets.

The Mandible. — (Pl. IV, Fig. 1.) The mandible is long and slender. The symphysis is long and the rami firmly united, displaying little or no trace of the suture, which is also true of the recent forms. The region anterior to the continuous molar-premolar series is comparatively heavier than that of the recent genera, owing to the presence of all the premolars. In this region there are also two slight constrictions, one in front and one back of pm. $\frac{}{1}$, which are not present in the recent forms. The ascending ramus compares well with the recent forms, especially the llama. The coronoid process is high, thin, and projects slightly backward at its extremity. The condyles have a comparatively greater transverse extension than in the recent forms. There is a strong hook-like process on the angle below the condyle, similar to that in the recent camel. In the llama this process is less pronounced. The masseteric fossa is much deeper than in the recent camel. In size, depth, and location it is more nearly like that of the llama.

The Foramina. — The inferior dental foramen is large and occupies a position similar to that of the recent forms. The mental foramen is placed low down on the jaw directly under the first premolar.

Cranial and Dental Variations in Lama huanaco. — In connection with the dental characters and some osteological features of the

cranium, it may be of interest to state some observations made upon a series of twelve skulls of *Lama huanaco*, which were taken from one and the same herd of upwards of one hundred animals, at Cape Fairweather, Province of Santa Cruz, Argentine Republic, South America, by Mr. J. B. Hatcher and the writer, during their explorations in that country.

The chief differences in structure and variations in position are observed in the third upper premolars. In some cases this tooth on one side occupies its natural position with its greatest diameter directed antero-posteriorly, while the corresponding tooth on the opposite side is placed transversely to the long axis of the alveolar border;[5] the external face thus becomes anterior, and by wear a most peculiar sharp transverse crest is developed on the anterior border of the tooth. In some instances the tooth on one side has two strong fangs and is naturally placed in the alveolar border, while the opposite tooth is set crosswise in the jaw and has only a single internal root, the external being seemingly absorbed by pm.$\frac{4}{}$. In one case the third premolar is present and well developed on one side and on the other side the corresponding tooth has dropped out and the alveole is entirely closed. In an old individual the third upper premolar is absent on both sides and the alveole on one side is entirely closed, while that of the other side contains a minute root, which, to judge from its soft spongy character, one would be justified in saying never carried a crown. (See Figs. 1 and 2.)

Another somewhat less noticeable character is the position of the inferior incisors. In the majority of cases the incisors have a recumbent position while frequently an individual especially an old one will be noticed with that series in an almost vertical position.[6]

The anterior palatine foramen and the posterior nares are quite variable in different individuals. The anterior palatine foramen is sometimes long and narrow and either somewhat anterior to the lateral incisor, directly opposite to it, or occupying a position posterior to it. Again the anterior palatine foramen may be shorter and broader, more oval in shape, and vary in position, with reference to the lateral incisors.

[5] In one case the fourth premolar has this transverse position while the tooth in front of it occupies its natural position in the jaw.

[6] In the collection is a skull and lower jaw of an adult female with but two incisors in the right mandible, while the left has the normal number.

The posterior nares are most remarkably variable, especially as to their shape, which ranges from a narrow lance-shaped to a wide U-

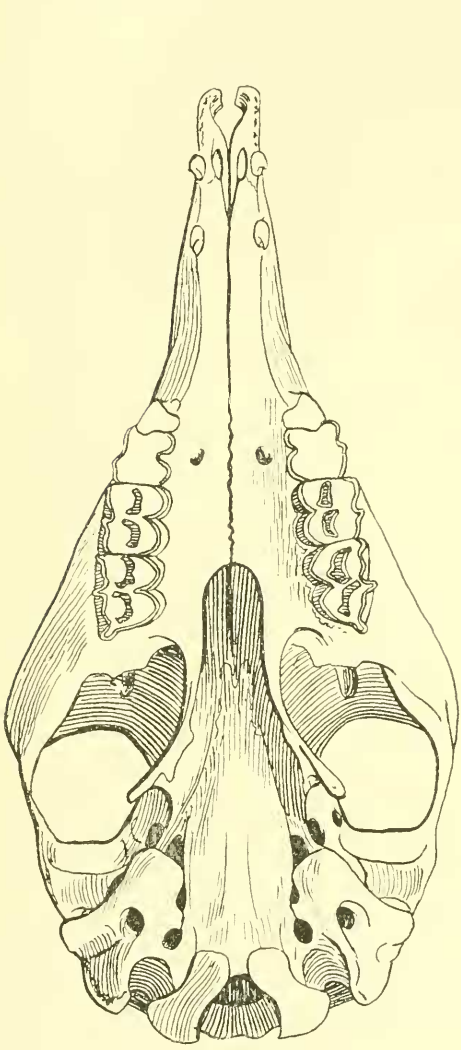

FIG. 1.

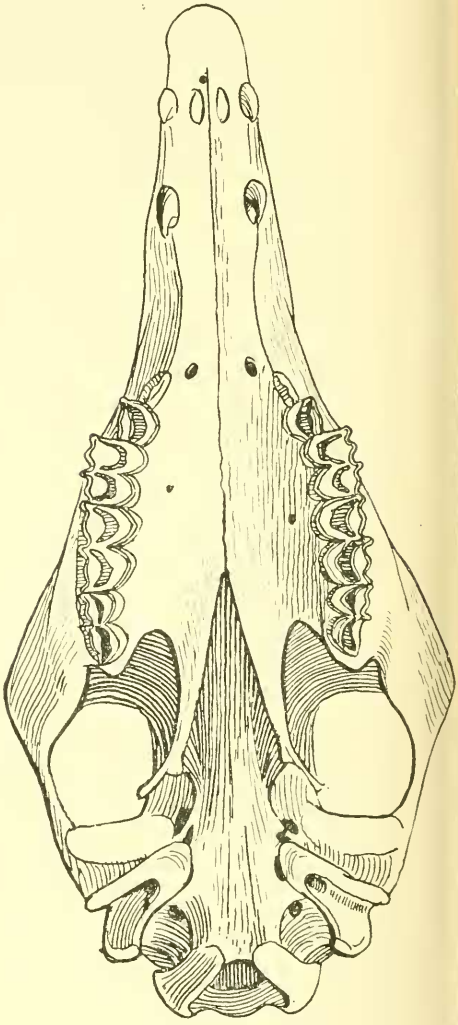

FIG. 2.

FIGS. 1 and 2. Palate views of skulls of two guanacos taken from the same band, at Cape Fairweather, Patagonia, showing remarkable individual variation in dental and cranial characters.

shaped anterior extremity. The position of their anterior border is also variable. Furthermore, the palatine fossa in different individuals varies in depth. (See Figs. 1 and 2.) Other differences might be pointed out, but they are less noticeable and are not very likely to be used in distinguishing one species from another.

From the observations noted above it may easily be seen how mistakes are unintentionally and sometimes unavoidably made in referring fragmentary material to the proper species or even genus.

COMPARATIVE MEASUREMENTS OF THE SKULL AND TEETH.

	O. longipes.	*C. bactrianus.*	*L. huanaco.*
Greatest length of skull	340 mm. [7]	540 mm.	305 mm.
Occipital condyle to apex of premaxillaries	318 mm.	496 mm.	287 mm.
Greatest expanse of skull at postorbital processes	126 mm.	241 mm.	150 mm.
Length of sagittal crest	95 mm. [7]	100 mm.	45 mm.
Length of nasals, median line	98 mm.		45 mm.
Length of palate from posterior			
Length of nares to apex of premaxillaries	182 mm.	281 mm.	150 mm.
Greatest breadth of palate including alveolar borders at m. 3	85 mm.	154 mm.	85 mm.
Greatest constriction of palate back of pm. 1	20 mm.	31 mm.	17 mm.
Length of continuous molar-premolar series	102 mm.	152 mm.	70 mm.
Length of diastema between incisor 3 and the canine	13 mm.	10 mm.	18 mm.
Length of diastema between canine and pm. 1	14 mm.	25 mm.	
Length of pm. 1 antero-posteriorly	9 mm.		
Length of diastema between pm. 1 and pm. 2	18 mm.		
Distance from canine to continuous molar-premolar series	40 mm.	91 mm.	55 mm.
Length of pm. 2	11 mm.		
Greatest breadth of pm. 2	6 mm.		
Greatest length of pm. 3	14 mm.	16 mm.	
Greatest breadth of pm. 3	20 mm.	15 mm.	
Greatest length of pm. 4	14 mm.	23 mm.	10 mm.
Greatest breadth of pm. 4	10 mm.	22 mm.	13 mm.
Greatest length of m. 1	19 mm.	34 mm.	16 mm.
Greatest breadth of m. 1	16 mm.	31 mm.	21 mm.
Greatest length of m. 2	23 mm.	44 mm.	21 mm.
Greatest breadth of m. 2	20 mm.	31 mm.	21 mm.
Greatest length of m. 3	25 mm.	45 mm.	26 mm.
Greatest breadth of m. 3	20 mm.	25 mm.	20 mm.
Distance from apex of premaxillaries to anterior margin of orbit	180 mm.	250 mm.	165 mm.

[7] This indicates the length measured by comparison with other individuals.

Distance from anterior margin of orbit to supra-occipitals	170 mm.	285 mm.	156 mm.
Antero-posterior diameter of orbit	45 mm.	67 mm.	50 mm.
Infero-superior diameter of orbit	36 mm.	63 mm.	50 mm.
Mandible.			
Greatest length of mandible including incisors	280 mm.	446 mm.	254 mm.
Greatest height of mandible including coronoid process	150 mm.	225 mm.	158 mm.
Height of coronoid process	48 mm.	77 mm.	50 mm.
Depth of ramus at m. 3	48 mm.	67 mm.	43 mm.
Depth of ramus at pm. 1	25 mm.	36 mm.	20 mm.
Length of diastema between canine and pm. 1	17 mm.	30 mm.	
Length of pm. 1 antero-posteriorly	9 mm.		
Length of continuous molar-premolar series	104 mm.	155 mm.	73 mm.
Length of diastema between pm. 1 and pm. 2	17 mm.		
Distance from canine to continuous molar-premolar series	45 mm.	110 mm.	63 mm.
Length of pm. 2	10 mm.		
Breadth of pm. 2	5 mm.		
Length of pm. 3	12 mm.		
Breadth of pm. 3	5 mm.		
Length of pm. 4	12 mm.	24 mm.	12 mm.
Breadth of pm. 4	7 mm.	16 mm.	8 mm.
Length of pm. 1	18 mm.	32 mm.	15 mm.
Breadth of pm. 1	10 mm.	28 mm.	13 mm.
Length of pm. 2	23 mm.	44 mm.	18 mm.
Breadth of pm. 2	14 mm.	26 mm.	15 mm.
Length of pm. 3	31 mm.	57 mm.	30 mm.
Breadth of pm. 3	13 mm.	21 mm.	15 mm.

The Vertebral Formula. — The vertebral formula in *O. longipes* appears to be as follows: Cervicals seven, dorsals twelve, lumbars seven, sacrals four and caudals fourteen (?).

In the type (No. 918), the cervical region and the sacrum is complete; there are six dorsals and four lumbars represented, but no caudals. While the caudal region is conjectural the writer is firmly of the opinion that in other respects the vertebral formula is correct, in view of the fact that it agrees with that of the recent Tylopoda, and was perhaps fully established in the Uinta representatives.[8] A skeleton (No. 562) which is referred to the genus *Oxydactylus* and has the complete cervical region, the five anterior dorsals, three or four of the

[8] In *Bull. Am. Mus. Nat. Hist.*, Vol. X, p. 107, 1898, Wortman describes *Protylopus petersoni* as having four sacrals, seven lumbars, and intimates that there are twelve dorsals.

posterior dorsals, with the complete lumbar region and sacrum, all in position and articulated by their zygapophyses save at the break in the dorsal region affords additional evidence as to the vertebral formula.

The Atlas. — (Pl. V, Fig. 1.) The atlas is proportionally long and narrow, in this respect more nearly resembling *Poëbrotherium* than the recent camel or the llama. The articulations for the occipital condyles are deeply concave, almost meeting inferiorly in the median line. Superiorly the notch is proportionally much narrower and somewhat deeper than in the recent forms. Externally each cotylus is notched like that of the recent Tylopoda. The dimensions of the cotylus are nearly alike in *O. longipes* and the specimens of the llama here used for comparison. The neural arches are also approximately of the same height. The spine is rudimentary as in the living genera. The keel on the inferior arch well developed but does not extend to the posterior margin as it does in the llama. There is a deep depression on either side of the median keel, which takes up the entire inferior surface of the atlas. Articular surfaces for contact with the accessory facets of the basi-occipitals are present on the anterior surface of the inferior arch, though absent in *Poëbrotherium*.[9] The articulation for the axis extends higher up on the arch and is comparatively narrower than in the recent camel and llama. This articulation is more vertical than in the llama and is quite distinct from that in any of the living forms.

Another character distinguishing the present genus from the recent camels is the posterior prolongation of the alæ. This seems to be the condition also in the other genera of the Loup Fork camels. In other respects the transverse processes are similar to those in the atlas of the recent camel and the llama. The foramen for the superior branch of the first spinal nerve compares well with that of the recent genera. Its posterior opening is located at the base and on the dorsal side of the transverse process.

The Axis. — (Pl. V, Fig. 2.) There is a striking similarity in the height and position of the neural spine and the shape of the odontoid process in the axis of *Oxydactylus longipes* and that of the recent camel. The spine overhangs the neural canal anteriorly as in the recent camel and extends backwards and gently upwards to the extreme posterior, border of the neural arch terminating above in a heavy and rugose tubercle. In the llama the spine does not over-

[9] *Journ. Morph.*, Vol. V, No. 1, p. 28.

hang in front but rises more abruptly, terminating above in the rugose tubercle, or knob, which forms the summit of the spine. The anterior opening of the vertebrarterial canal is placed well forward and has the same lateral position as in the recent camel and the llama. The external opening is divided by a heavy bony plate, while that of the recent forms is undivided. A tendency to divide in the recent genera, especially in the llama, is sometimes shown by a short process on the anterior border of the opening. The odontoid process has a less spout-like appearance than in the llama, in this repect more nearly resembling that of the recent camel. The transverse processes and the inferior keel of the axis are proportionally lighter, and the latter is less rugose but more produced than in the camel and the llama, the expansion of the zygapophyses in *O. longipes* is not so great as in recent forms.

The length of the axis in comparison with that of the third cervical is entirely different from that which obtains in any of the living forms. In the recent camel the axis is the longest cervical. In the llama the axis and the third cervical are of nearly equal length, while in *O. longipes* the axis is much shorter than the third cervical.

The Third Cervical. — The third cervical vertebra is the longest in the vertebral series. The neural spine is proportionally higher than in the llama, but the laminæ, extending from the spine to the postzygapophysés as seen in the llama, are wanting. The spine is lighter, but higher, than in recent forms. The anterior and posterior divisions of the transverse process are nearly as well developed and occupy the same relative position as in the llama, *i. e.*, the anterior process is placed somewhat lower down on the centrum and is directed outward, downward, and forward, while the posterior process is situated higher on the centrum and is more nearly horizontal. The inferior keel is a prominent rugose tubercle and extends more downward, but is not so heavy as that of the llama. In the type, the keel does not extend so far forward as in the llama, while other individuals of the same genus show a faintly marked keel throughout the entire length of the centrum. The pedicles are deeply notched, especially anteriorly, to admit the passage of the spinal nerves. On this vertebra, there is no visible vertebrarterial canal. From the base of the prezygapophysis there is a sharp ridge extending posteriorly along the pedicle for some distance, which is similar to that in *Poëbrotherium* and the recent forms. The postzygapophyses are heavier than the prezygapophyses and more expanded laterally.

Fourth Cervical. — The fourth cervical is essentially a duplication of the third, except that it is heavier. The spine differs from that in recent forms by being broader antero-posteriorly. It extends uninterruptedly backwards to the base of the postzygapophyses. The inferior keel is heavy and terminates in a rugose knob at the posterior inferior end of the centrum. There is no vertebrarterial canal.

The Fifth Cervical. — The fifth cervical is about 20 mm. shorter than the fourth, but heavier than that vertebra. The neural spine more nearly resembles that of the same vertebra in recent forms being somewhat depressed posteriorly and broad superiorly. The anterior division of the transverse process is directed downward and forward extending somewhat in advance of the centrum, similar to that of the llama. The inferior keel is as prominent as that of the fourth cervical. The other characters are similar to those of the latter vertebra.

Sixth Cervical. — The sixth cervical is proportionally shorter than is that in the llama and retains the characters seen in that of *Poëbrotherium*. The corresponding vertebra in the recent camel is remarkably similar in character while that of the llama is widely different. In *Oxydactylus* the centrum is 39 mm. shorter than that of the fifth, more strongly convex anteriorly, and somewhat more concave posteriorly than any of the preceding vertebræ. The inferior keel is well represented. The neural spine is high, similar to that of the camel and occupies the entire length of the superior border of the neural arch. In the llama the spine is represented by a low heavy ridge which is confluent with the postzygapophyses, while in *Oxydactylus longipes* and the recent camel the spine is entirely independent and extends to the posterior margin of the neural arch. The transverse process is like that of the llama, a thin plate of bone occupying a considerable portion of the side of the centrum. The inferior lamella, as in *Poëbrotherium*[10] and *Camelus bactrianus*, is not divided, while in the llama there is a distinct posterior and anterior division of this element. In the type, this lamella occupies the entire length of the inferior and exterior part of the centrum, pointing downward and outward; the anterior and posterior terminations are rounded tubercles connected by a thin and slightly emarginated plate of bone. The vertebrarterial canal is located in the pedicle as is that in the llama.

The Seventh Cervical. — The seventh cervical is approximately 30 mm. shorter than the sixth. The anterior face of the centrum is de-

[10] *Journ. Morph.*, Vol. V, No. 1, p. 26.

cidedly hemispherical and the whole body of the centrum anteriorly has a decurved position resulting in a greatly curved keel. Posteriorly this vertebra is restored and the characters in this region are conjectural. The restored parts are indicated in the illustrations by broken lines. The anterior portion of the neural spine is preserved as it was found in position in the rock and indicates a high laterally compressed plate of bone similar to that of the recent camel and much unlike the low heavy spine of the llama. The anterior zygapophyses are greatly expanded, and the transverse processes are heavy and in general character resemble those of the living forms.

Cervical vertebræ are rare among the Loup Fork camel remains so far obtained, and some disappointment is therefore met with in a comparative study of them. When more complete material of the different genera and species are discovered we shall undoubtedly be able to determine whether or not the axis, as in *Camelus*, is the longest vertebra in the cervical series in any of the Loup Fork forms, or, if they all, as in the llama, had the third and fourth cervical the longest. On the whole, the structure in the cervical region of *O. longipes* is far more similar to that of the llama than to that of the recent camel. The strong downward curve of the posterior cervicals which brings the cranium more nearly on a level with the vertebral column in *Camelus* seems to have been less apparent in *O. longipes*. The latter genus probably carried the head higher than the former.

The Dorsals.—There are six dorsal vertebræ represented in the type specimen. Their relative positions as determined are the first, fifth, sixth, seventh, ninth, and tenth, assuming that there were twelve dorsals, which was the probable number.

The First Dorsal.—The centrum of the first dorsal is approximately 18 mm. shorter than that of the last cervical, and also less opisthocœlous. Inferiorly the centrum presents a faintly marked median keel with strong lateral ridges. Between the lateral ridges and the capitular facet is a deep pit or groove, which is also present on this vertebra in recent forms. The neural spine is high, laterally compressed, and comparatively broader than that in the camel and the llama. The prezygapophysis and the tubercular facet together form a heavy transverse process. The prezygapophyses are greatly expanded and are placed low down, giving a depressed appearance to the vertebra. The postzygapophysial facets of opposite sides are confluent. In the camel and the llama there is a decided groove separating the two facets.

Dorsals Two to Twelve. — As before stated, there is a break in the vertebral column of the type specimen, between dorsals one and five, three vertebræ being entirely absent. From other material (No. 562) it is evident that the second dorsal has a shorter centrum than the first, as in the camel, while in the llama the two are about equal. It appears that the median ridge on the inferior face of the centrum is well marked, but the pits referred to in describing the first dorsal are nearly obsolete. From the material at hand it is obvious that the spine is higher and narrower than that on the first dorsal, and that it increases in height until the fifth vertebra is reached, and in width until the sixth, which also seems to be true in the recent forms. The third and fourth vertebræ are apparently very similar to the second. The posterior part of the centrum of the fifth dorsal is present in the type and was found in position with the two succeeding vertebræ which were interlocked by their zygapophyses when found. The centra of these two vertebræ (sixth and seventh) are more laterally compressed, and somewhat higher proportionally than are those of the preceding dorsals. The neural canal is moderately large. The transverse processes are comparatively heavy, and the zygapophyses have that peculiar continuous articulation from side to side referred to in the description of the first dorsal. The ninth and tenth dorsals are complete including the neural spines and present characters similar to that of the sixth and seventh. The transverse processes on the ninth and tenth dorsals are greatly reduced. The neural spines are broad and thin. The spine on the tenth dorsal is slightly recurved superiorly, in anticipation of the erect spine of the anticlinal or twelfth vertebra. The postzygapophysis on the tenth dorsal has a small groove separating the articulating facets while the prezygapophyses of the ninth indicate a continuous facet. The eleventh and twelfth dorsals are missing in the type.

The Lumbar Vertebræ. — In the type of this genus the three anterior lumbars are missing. The four vertebræ present were found interlocked by their zygapophyses and also attached to the sacrum. In skeleton No. 562 the first four lumbar vertebræ have their centra of equal length, while the centra of the following vertebræ become shorter, the last being the shortest, broadest, and most depressed in the series. The lumbars present in the type show less development of the inferior keels than is shown in the recent camel and the llama, and differ from the latter genera by having strong lateral

ridges on either side of the median line or keel. The zygapophyses have the usual interlocking features, with evidence of the presence of episphenial processes, although not constant throughout the series. The neural spines have a greater forward slope than those of the recent genera. Posteriorly and near the base the spines send heavy laminæ to each postzygapophysis, thus forming a deep triangular pit back of the base of the spines; a character which is almost entirely absent in the recent camel and the llama. A great similarity between *Oxydactylus longipes* and the recent forms is noticeable in the transverse processes. In the type specimen these are preserved in some instances for more than half their estimated length. The left transverse process on the last lumbar is complete and is proportionally flatter than in that of the recent genera, especially the camel, in which the corresponding process is more nearly circular in cross-section.

The Sacrum. — (Pl. VI, Fig. 8.) There are four firmly coössified centra in the sacrum of *Oxydactylus longipes*. This region of the vertebral column is proportionally somewhat lighter than in the recent forms, as will appear from the comparative measurements. The sacrum of *Oxydactylus longipes* is but very little longer, while the greatest lateral expansion is actually less than that of the llama. The first sacral is broad, nearly flat inferiorly, and sends out heavy pleurapophyses to meet the ilium, which is supported only by the first sacral vertebra. The neural spines, as in recent forms, are very light, the arches greatly depressed and thin, especially in the first and second sacrals. The last two sacrals have comparatively heavy rounded spines and the centra assume a cylindrical form more like those of the caudal vertebræ.

The Caudals. — In skeleton No. 562 there is preserved only a single fragment of a median caudal. Judging from the rapid tapering of the centra in the sacrum the tail was not longer than that of the camel, or may even have been shorter.

The Ribs. — There are in the type (No. 918) a number of rib fragments, including the first rib on one side nearly complete. The general form of the ribs resembles that of the recent species. The first rib is short, subcylindrical proximally, and considerably more flattened and expanded distally. The fragmentary remains of the ribs indicate that they were broad and rather thin in the anterior half of the thorax, while they become more rod-like posteriorly. The short distance between the head and the tubercles of the ribs would seem to indicate a rather small thorax. No sternal bones are known.

COMPARATIVE MEASUREMENTS OF THE VERTEBRAL COLUMN.

	O. longipes	*C. bactrianus.*	*L. huanaco.*
Greatest length of atlas	80 mm.	105 mm.	58 mm.
Greatest breadth of atlas	75 mm.	122 mm.	76 mm.
Length of atlas median line inferiorly	43 mm.	61 mm.	34 mm.
Greatest breadth of cotyle	55 mm.	105 mm.	52 mm.
Height of atlas posteriorly, including the inferior tubercle	42 mm.	75 mm.	44 mm.
Greatest length of axis	158 mm.	220 mm.	121 mm.
Length of centrum	138 mm.	180 mm.	102 mm.
Length of odontoid process	20 mm.	24 mm.	16 mm.
Greatest height of axis	65 mm.	104 mm.	60 mm.
Greatest width of centrum anteriorly	51 mm.	85 mm.	49 mm.
Greatest length of third cervical	195 mm.	190 mm.	124 mm.
Length of centrum of third cervical anteriorly	174 mm.	165 mm.	110 mm.
Width of centrum of third cervical	26 mm.	44 mm.	26 mm.
Greatest length of fourth cervical	191 mm.	185 mm.	124 mm.
Length of centrum of fourth cervical	176 mm.	162 mm.	108 mm.
Width of centrum of fourth cervical anteriorly	34 mm.	50 mm.	29 mm.
Greatest length of fifth cervical	169 mm.	183 mm.	119 mm.
Length of centrum of fifth cervical	150 mm.	158 mm.	100 mm.
Width of centrum of fifth cervical anteriorly	34 mm.	55 mm.	31 mm.
Greatest length of the sixth cervical	135 mm.	175 mm.	102 mm.
Length of centrum of the sixth cervical	110 mm.	140 mm.	83 mm.
Width of centrum of the sixth cervical anteriorly	37 mm.	61 mm.	33 mm.
Greatest length of seventh cervical	*100 mm.	138 mm.	78 mm.
Length of centrum of seventh cervical	*77 mm.	115 mm.	59 mm.
Width of centrum of seventh cervical anteriorly	37 mm.	64 mm.	35 mm.
Greatest length of first dorsal	78 mm.	115 mm.	55 mm.
Length of centrum of first dorsal	55 mm.	79 mm.	39 mm.
Height including spine of first dorsal	125 mm.	215 mm.	105 mm.
Width across transverse processes of first dorsal	87 mm.	125 mm.	73 mm.
Length of centrum of fourth lumbar	53 mm.	71 mm.	45 mm.
Length of centrum of fifth lumbar	50 mm.	71 mm.	44 mm.
Total length of centra of fourth, fifth, sixth and seventh lumbars	205 mm.	265 mm.	165 mm.
Greatest length of sacrum	*142 mm.	211 mm.	130 mm.
Greatest width of sacrum	110 mm.	195 mm.	120 mm.
Greatest width at posterior end of sacrum	41 mm.	75 mm.	43 mm.

THE SCAPULA AND FORE LIMB. (Pl. VII, Fig. 1.)

The scapula is longer than in the llama. The neck is longer and more constricted. The coracoid is proportionally less prominent, and the spine overhangs the postscapular fossa more than it does in the llama. In the type the spine begins 35 mm. above the glenoid cavity

and extends in a curved line nearly to the superior border, dividing the blade into a greater post- and lesser pre-scapula. Superiorly the scapula is comparatively much broader than that of the camel, which has a long and slender scapula with the pre- and post-scapulæ more nearly equal. The acromion is broad.

The Humerus. — (Pl. VII, Figs. 2 and 3.) With the exception of the tuberosity, the humerus of the cotype (No. 886) of this genus is well preserved. Other material in the museum collections supplement this and the humerus agrees in its chief characters with Cope's description of that in *Procamelus occidentalis.*[11] Of the latter Cope says, "The humerus is rather slender, and is characterized by the large size of the tuberosities. They are connected at their bases, the connecting mass enclosing a deep fossa with the head, or condyle. The greater tuberosity is produced much beyond the head proximally, but not much beyond the line of the anterior border of the shaft." In the cotype the head is comparatively as large as that of the llama, and fully as convex. From material at hand it appears that the bicipital groove is so situated that in a direct front view it appears on one side while that of the camel and the llama is exactly in front. The deltoid ridge and hook, as well as the supinator ridge, is fully as well developed as in the recent forms. The distal end of the humerus is proportionally narrow, and as in *Poëbrotherium* the trochlea is more oblique to the long axis of the shaft and extends higher up on the bone posteriorly than it does in the llama. In *Camelus* this character is more nearly like that in *O. longipes.* The internal epicondyle has a greater development in *O. longipes* than in the recent forms. The external epicondyle is less developed and is more like that of the recent camels. The anconeal fossa is narrow and high. There is no evidence of a supratrochlear foramen. The appearance of the humerus aside from the greater development of the tuberosities, compares closely with that of the llama. The deltoid crest is turned backward. The bone is light, in harmony with the slender proportions of the limb.

The Ulna and Radius.— (Pl. VIII, Fig. 1.) There is preserved in the type only the proximal end of the ulna and radius. The cotype (No. 886) has both bones present. The two bones are as completely coössified as in the recent forms. The shaft is as straight as that of the camel and less curved than that of the llama. The head

[11] "U. S. Geogr. S.," Part II, Vol. IV, p. 533, 1877.

of the radius is narrow. The external articular facet for the humerus is much larger than the internal, and, as in recent genera, it is not continuous with the superior border of the sigmoid notch. The internal facet passes upward without interruption to the summit of the superior process. The two facets are concave and are divided by a rounded ridge which also extends uninterruptedly to the upper extremity of the sigmoid notch. The olecranon process is moderately long, comparatively light, and much compressed laterally, and is directed backwards and upwards from the sigmoid notch. In having the groove on the anterior face well developed for the extensor tendon *Oxydactylus* differs entirely from the recent camel and the llama. *Poëbrotherium* has also this groove well developed. The truncated superior end of the olecranon process of *Oxydactylus longipes* is comparatively lighter than that of the recent genera. The proximal half of the ulnar shaft is concealed by the radius when viewed from the front. Midway the shaft of the ulna appears on the external side of the radius and forms a sharp ridge thus broadening the shaft composed of the combined radius and ulna which is decidedly wider distally than proximally. In the skeleton of *Lama huanaco*, here used for comparison, the ulna like that of the camel has a more external position throughout the entire length of the radial shaft. This may be due to individual variation, since Scott says that the ulna in the llama is almost entirely posterior in position.[12] In the type the bicipital tuberosity is small as in *Poëbrotherium* and occupies the internal border immediately below the head as in the recent forms. Distally there are three distinct facets which are more nearly equal in width than in the recent camel and the llama. The median and external facets are proportionally wider than in the latter genera. The three facets are more oblique to the transverse axis of the shaft than they are in the llama. The scaphoid articulation is concave anteriorly where it is more elevated than the convex posterior part, which is carried high up on the posterior face of the radius, conditions similar to those seen in the recent genera. The lunar articulation is wider anteriorly than posteriorly and presents a subtriangular facet, which is well separated from the scaphoid and cuneiform facets by high ridges. Like the scaphoid the lunar facet is concave in front and convex behind, and is reflected on the posterior face of the radius but in a lesser degree. The cuneiform facet is proportionally narrower than in the llama, and

[12] *Journ. Morph.*, Vol. V, No. 1, p. 32, 1891.

as in the latter it is saddle-shaped, convex antero-posteriorly and concave laterally. The pisiform articulation on the shaft is almost continuous with the cuneiform facet and is placed as high as the upper margin of the posterior scaphoid facet. The inner angle of the radius is as well developed in *O. longipes* as in the llama.

The Scaphoid. — The scaphoid (No. 886) is proportionally smaller than in the llama, but resembles it in its general characters. In the cotype this bone is narrow transversely and deep antero-posteriorly. The anterior part of the proximal articulation is a broad convex ridge, and the posterior part is concave and terminates in an elevated, sharp, hook-like border. The inner side is rounded and rugose, the external ulnar surface is a vertical plane with three distinct facets for the lunar, which are as well developed as those of the llama, the anterior facet near the distal end being the smallest of the three. Between the last mentioned facet and the posterior rounded facet, there is a deep triangular pit, with its broad exit directed downward. Distally the scaphoid has two facets, for the trapezoid and the magnum. The first mentioned is a rounded concavity on the postero-radial part of the bone and the magnum facet is flat and occupies the entire anterior face.

The Lunar. — The lunar (No. 886) is proportionately greater in size than is that of the llama and the camel. The wedge or beak extends below both scaphoid and cuneiform when in position in the carpus. The bone is as broad as the scaphoid and higher. Its antero-posterior diameter is nearly as great as that of the scaphoid. This is chiefly due to the long, heavy, posterior arm, which greatly exceeds that of the llama in size. The proximal articulation is irregularly convex fore and aft and somewhat triangular in shape. The radial side has three facets corresponding to those of the scaphoid with which it articulates. On the radial and ulnar sides the lunar is deeply excavated and the bone has an elongated vertical appearance, especially when seen from in front.

There are two posterior processes, the shorter projects outwards and downwards on the ulnar side, abutting against the cuneiform and unciform, the longer process extends posteriorly, slightly radially and has a beak-like decurved tubercle which forms the apex of the facet for the magnum. Distally the unciform and magnum facet are equal in size and meet nearly at right angles, thus forming a wedge-shaped beak, which is longer than is that in the llama and the camel.

The Cuneiform. — As in *Poëbrotherium* the cuneiform in the cotype (No. 886) is high, narrow and deep, not nearly so massive as that of the llama and has a greater concavity on the proximal articular facet for the ulna than it has in the latter genus. The convex posterior facet for the pisiform extends somewhat farther forwards, especially on the radial side of the bone, thus giving a shorter oblique facet for the distal end of the ulna than is seen in the llama. The radial side is deeply excavated and has two facets, one superior and one inferior, the latter much less deeply excavated than is that of the llama, which fact is due to the lesser angularity of the posterior bifid projection of the lunar in *O. longipes*. The external or ulnar face of the cuneiform is rounded and rugose. Distally there is a single facet, concave antero-posteriorly, for articulation with the unciform.

The Pisiform. — The pisiform (No. 886) is shorter and comparatively heavier than that of the llama. The cuneiform facet has a more rounded face and equals the ulnar facet in size, while in the llama the latter is somewhat larger. The free end of the bone is thicker and more rugose, although not attaining the vertical depth which is seen in the recent genera. The neck of the pisiform is more constricted in *O. longipes* than in the llama.

The Trapezoid. — The trapezoid (No. 886) is a rounded nodular bone and is proportionally not so deep as in the llama. The proximal articular surface for the scaphoid is rounded much in the same manner as in the recent genera. On the radial side the magnum facet is divided, the inferior part being the larger, while in the llama the superior part is the larger of the two. The ulnar face is very rugose and rounded and the postero-internal face carries an irregularly quadrilateral facet extending from the distal margin half way up the total height of the bone and articulating with the rudimentary trapezium. Distally there is one flat facet similar to that of the camel and the llama.

The Trapezium. — The trapezium is a small oblong nodule greatly resembling a sesamoid. There are two facets on the trapezium, one antero-superior which is flat and articulates with the corresponding facet on the trapezoid; the other facet is antero-inferior, slightly concave, ovate in shape and articulates with the adhering scale-like second metacarpal.

The Magnum. — The magnum (No. 918) is proportionally longer antero-posteriorly than in the llama and has a greater constriction in front of the posterior hook and rather resembles that bone of the re-

cent camel. Proximally the magnum articulates with the lunar and scaphoid. The facet for the former is regularly convex and meets the concave lunar facet. The latter is flat and irregularly triangular in outline. The cavity for the trapezoid is nearly rectangular and it more nearly resembles that of the camel than the llama. In the latter genus the cavity for the trapezoid is a very oblique opening, with walls slanting upwards and inwards. The ulnar side is excavated and has two facets, one anterior and one posterior, both articulating with the unciform. The anterior facet is continuous with the lunar facet, which is situated above, without a distinct dividing ridge, as is seen in the llama and the recent camel. The posterior facet is located on the free end of the tubercle on its posterior-ulnar side. Distally the magnum has one single broad triangular and flat articulation, somewhat recurved posteriorly, forming a blunt beak for articulation with metacarpal three.

The Unciform. — The unciform in the type (No. 918) is narrow and long. The great development of the posterior decurved hook-like process greatly increases the length of the bone. Proximally the unciform has two facets, the lunar and the cuneiform, which are divided by a high sinuous ridge. The lunar facet is the larger and is deeper than is that of the llama. The cuneiform facet is long, narrow and irregularly curved. There are three facets on the radial side of the unciform, the two superior facets articulate with the magnum, and the inferior facet meets the external side of the proximal end of the third metacarpal. The deeply excavated pit which appears in front of the tubercle on the radial side in *O. longipes* is represented only by a slight cavity in the llama. In the camel this cavity is somewhat deeper but not so deep as in *O. longipes*. Externally the unciform is rounded and rugose. The distal articulation for metacarpal IV is slightly concave and occupies the entire distal surface of the bone. The unciform of *O. longipes* more nearly resembles that of the recent camel than that of the llama. The greatly developed posterior hook on the unciform in *Oxydactylus* is generally characteristic of the Loup Fork camels.

The Metacarpals. — (Pl. VIII, Figs. 2 and 3.) On the sides of the functional third and fourth metacarpals of (No. 886) there are small, flat, rugose ossicles, representing metacarpals II and V. Metacarpals III and IV are entirely separated and proportionally more elongated than in the recent genera. The upper two thirds of the shaft is laterally much compressed. The distal portion is D-shaped in cross-sec-

tion. The two bones are closely applied to each other with roughened surfaces throughout nearly their entire length. Distally they are slightly separated. Metacarpal III is proportionally heavier than that of the llama. Proximally the head rises above that of metacarpal IV, and carries four facets for articulation with the unciform, magnum, trapezoid and trapezium, respectively. The magnum facet is slightly concave and occupies the anterior face, while the posterior facet for the trapezoid is more elevated and extends downward on the posterior face of the bone. The decurved part of the latter facet, although without a distinct separation from that for the trapezoid, serves to articulate with the ovate-shaped facet referred to as present on the trapezium. On the ulnar side, near the anterior face, there is a process with a rounded articular face, which abuts against a corresponding facet on the unciform. Immediately below this process is the articulation for metacarpal IV. The radial face of metacarpal III is comparatively flat and broad, the anterior narrow and very convex. The ulnar face is flat, rough, and is closely applied to metacarpal IV. Posteriorly the two metacarpals have prominent lateral ridges, thus forming a wide, deep groove in the median line, which extends from the proximal end down the shaft two thirds of its length. The lateral posterior ridge is much more pronounced on metacarpal III than metacarpal IV. In the recent camel and llama the posterior ridges on the metacarpals are more nearly equal in size and the median depression is comparatively shallow. Half way down on the shafts of the metacarpals of *O. longipes* the cross-sections gradually take on a D-shaped form which is continued to the distal trochlea. In the early forms referred to the Tylopoda the distal trochlea is very narrow, a character which is retained in *O. longipes*, the trochlea being scarcely any wider than the shaft of the bone. In the recent camel and llama the trochlea is wide, but the carina is much stronger in *O. longipes* than in these genera. Metacarpal IV is lighter, slightly shorter and more angular in cross-section near the proximal end than metacarpal III. The proximal end has a single articular facet for the unciform. Another small facet is seen on the antero-radial side for articulation with metacarpal III. The shaft has less depth antero-posteriorly than that of the third metacarpal. The size of the distal end, including the trochlea, is more nearly equal to that of metacarpal III than is the proximal end of the bone, and the phalanges of the two digits are about equal in size.

The Phalanges. — The phalanges of the type (No. 918) are proportionally shorter than they are in the recent camel and llama, and are less symmetrical. The proximal ends of the first row of phalanges have the concave articulations for the metapodials much deeper than those of the llama and the recent camel. The grooves for the metapodial keels are deep and there is a nodular tuberosity on either side of the groove on each phalanx which is well illustrated in Pl. VIII, Fig. 3. In the camel and the llama the metapodial groove is shallow and the rugosity for the attachment of the pad extends well forward. Distally the trochlea is deeper and more oblique than in the recent camels, and external keels do not extend as high up on the posterior face of the shaft. The phalanges of the second row have a decided ridge separating the articular facets articulating with the proximal phalanx. This ridge is obsolete in the recent genera. As in *Poëbrotherium* the second row of phalanges are proportionally longer than in the recent Tylopoda. The phalanges of the first and second row in *O. longipes* do not seem to have changed any in character from those of *Poëbrotherium.*[13] Cope says that "the phalanges (in *Procamelus occidentalis*)[14] only differ from those of the llama in the greater prominence of the proximal ligamentous insertions and the rather more slender shafts." If the illustration is correct in Plate LXXIV in the publication just referred to, it is obvious that the proximal phalanx in *P. occidentalis* is like that of *O. longipes* and without the plantar rugosity for the attachment of the pad. The comparative length of the bone, however, is more like that of the llama than is the corresponding bone in *O. longipes.*

The Unguals. — The ungual phalanges in *O. longipes* are comparatively short, laterally compressed, pointed and high; they have not changed in shape from those of *Poëbrotherium* while in comparative length there seems to be considerable difference, the former genus having the unguals more reduced than the latter. The phalanges in *O. longipes*, as a whole, seem to retain characters seen in the early Oligocene forms, while other Loup Fork genera[15] have unmistakably taken on these tylopod characters, such as the rugosity on the plantar face for the pad and the general flattening of the median phalanx.

[13] *Journ. Morph.*, Vol. V, No. 1, p. 37, 1891.

[14] "U. S. Geogr. S.," Vol. IV, Part II, p. 337, 1877.

[15] Specimens in the American Museum studied by the writer.

COMPARATIVE MEASUREMENTS OF FORE LIMBS AND FEET.

Mark in front of figures denotes comparative measurement made with other individuals of same species.

	O. longipes.	*C. bactrianus.*	*L. huanaco.*
Greatest length of scapula	288 mm.	477 mm.	225 mm.
Greatest width of scapula	190 mm.	235 mm.	155 mm.
Width of neck of scapula	42 mm.	77 mm.	41 mm.
Width of humeral articulation including coracoid process of scapula	65 mm.	106 mm.	55 mm.
Width of prescapula [16]	65 mm.	90 mm.	86 mm.
Width of postscapula	100 mm.	127 mm.	48 mm.
Greatest height of spine	34 mm.	50 mm.	28 mm.
Greatest length of humerus	*315 mm.	380 mm.	287 mm.
Greatest length of radius and ulna	*440 mm.	462 mm.	347 mm.
Width of radius at the head	47 mm.	87 mm.	47 mm.
Width of shaft below the head	35 mm.	71 mm.	35 mm.
Height of carpus	*38 mm.	65 mm.	35 mm.
Width of carpus	*50 mm.	91 mm.	43 mm.
Greatest transverse diameter of unciform	25 mm.	36 mm.	21 mm.
Height of unciform	17 mm.	28 mm.	15 mm.
Antero-posterior diameter of unciform	40 mm.	53 mm.	28 mm.
Antero-posterior diameter of magnum	28 mm.	33 mm.	24 mm.
Greatest breadth of magnum	22 mm.	40 mm.	20 mm.
Height of magnum	16 mm.	19 mm.	12 mm.
Length of metacarpals	345 mm.	330 mm.	230 mm.
Breadth of distal end of metacarpal 3	23 mm.	45 mm.	23 mm.
Breadth of distal end of metacarpal 4	23 mm.	45 mm.	23 mm.
Length of proximal phalanx	66 mm.	100 mm.	77 mm.
Length of median phalanx	31 mm.	65 mm.	27 mm.

THE PELVIS AND HIND LIMB.

The Pelvis. — (Pl. IX, Figs. 1 and 2.) The general appearance of the pelvis is strikingly different from that of any of the living camels. It is depressed, greatly elongated, and but little expanded, being especially narrow posteriorly. In the camel and the llama the pelvis is short and much expanded and when in position the longer axis is inclined at a higher angle than in *O. longipes*. In the type (No. 918), the most important parts of the pelvis are preserved and they present the characters which we proceed to describe. The antero-superior border of the ilium is not entirely complete but indicates

[16] Measurements taken of type 60 mm. below the suprascapular border where the bone is complete. Measurements of the other genera are taken in a corresponding manner.

the greatly expanded condition of the ilium in this region. The constriction back of the surface for contact with the sacrum is similar to that in the llama. The peduncle is comparatively long, and the acetabulum is deep. The ilium, ischium, and pubis unite to form the acetabulum in much the same manner as in recent forms. The superior border of the ischium is high, sharp, and as in the llama, has many small ridges for muscular attachments running from the superior margin across the entire external surface. The posterior portion of the ischium is wanting. The pubis is proportionally short and stout. The shaft is more circular in cross-section than is that of the recent forms. The distal end is narrow, long and thick, instead of broad and short as in living forms. The thyroid foramen is large and ovate in shape. The elongate and narrow pelvis of *O. longipes* contrasts strongly with the broad and shorter pelvis of the recent species as will appear from the following measurements of these elements in *Oxydactylus longipes* and *Lama huanaco*. In the former the width across the pelvis at the acetabular region is 135 mm. while that of the latter is 165 mm., a difference which seems all the more marked when we consider that *O. longipes* is on the whole the larger animal of the two.

The Femur. — (Pl. IX, Fig. 3.) The femur has a comparatively slender sinuous shaft, subcircular in cross-section, greatly expanded both proximally and distally and in general appearance resembling that of the llama. The head is smaller, the ovate pit for the *ligamentum teres* shallower, but its position is the same as in the recent genera. The head is separated from the shaft by a longer and more constricted neck than in the llama and camel. The great trochanter is higher, not so heavy superiorly, and has not as great an obliquity to the long axis of the bone as in the llama. The bridge from the head to the greater tuberosity being rather short, the digital fossa is accordingly narrow laterally, though fully as deep as is that of the llama. The lesser trochanter is a prominent knob unlike the sharp rugose ridge seen in the llama and decidedly more prominent than is that of the camel. At the base of the lesser trochanter there begins a prominent ridge for muscular attachment which continues downward on the posterior face of the bone. The same ridge is found in the llama and the camel. The rotular trochlea as well as the condyles are comparatively narrow, the external condyle being the larger of the two. The intercondylar notch is narrower than in the llama.

The Patella. — There is no patella with the type, but it is present in another skeleton (No. 562), where it is thinner, broader, and much shorter than is that of the llama. The superior border is the broadest and the outline is that of a long triangle with the apex directed downward.

The Tibia. — The tibia in *O. longipes* is longer than the femur, while in the camel the femur is much the longer bone of the two. In the llama the two bones are of equal length. In *Poëbrotherium* the tibia is apparently longer than the femur. The shaft is long, slender and straight, the lower half being suboval in cross-section. Proximally there is a great expansion equaling that in the llama. The articulations for the femoral condyles are broad laterally, slightly convex antero-posteriorly, and, as in the llama, the external facet is the larger, and is separated from the internal by the bifid spine. The cnemial crest is comparatively heavier and extends lower down on the shaft than does that of the llama and the camel. Distally the external facet for the astragalus is proportionally wider, and the internal narrower than that of the llama, resembling that of the camel more closely in this respect. In the latter the internal malleolus is placed anteriorly and in such a way as to present a constriction on the anterior half on the internal facet, similar to that found in *O. longipes*. In the llama the external facet is entirely without this constriction. The fibular facet is comparatively smaller than in the llama. This is especially true of that portion anterior to the groove which divides this facet. In the type of *O. longipes* the external astragalar facet has a pit which is comparatively smaller than that of the camel.

The Fibula. — The fibula, as in modern representatives of the Camelidæ, is reduced to the malleolus which articulates with the tibia, astragalus and calcaneum. The rudimentary process of the shaft is proportionally heavier than in the recent genera. It is triangular in cross-section, terminates in a sharp point superiorly, and fits closely into the deep groove on the external face of the tibia.

The Tarsus. — The tarsus of *Oxydactylus longipes*, as compared with that of the camel and llama, is higher and much narrower, as would be expected from the lighter structure of the entire limb already noticed. The calcaneum is much longer, but of less diameter antero-posteriorly than is that of the llama. The free truncated end of the tuber shows characters similar to those of the recent genera. The fibular facet is less prominent and is placed at a greater obliquity to

the long axis of the calcaneum than in the camel, and is more nearly like that of the llama. The facet for the cuboid is somewhat longer antero-posteriorly than in the llama but the inferior projecting articular lip, which embraces the distal end of the astragalus in the camel and the llama is entirely absent in *Oxydactylus longipes*. There are no important differences from that of living genera in the sustentacular facet. Below the latter facet and above that of the cuboid is an opening, but not nearly so distinct as is seen in living forms. The groove on the posterior face immediately above the cuboid facet is deeper than that in the llama and resembles that of the camel.

The Astragalus.— The astragalus is comparatively much longer and narrower than that of the camel and llama. Anteriorly there is more of a constriction and a greater separation between the proximal and distal trochlea than in the recent genera. The internal condyle is not nearly so heavy as that of the llama, except at the posterior apex, where it has a slightly recurved shoulder not observed in the camel or the llama. The articulation is continuous without the interruption observed on the lateral side of the condyle of the camel. In the llama this articulation is also uninterrupted. The external condyle is comparatively lower in *O. longipes* than in the camel giving the bone a more symmetrical appearance than in the latter genus. The distal trochlea is similar to that of the camel and the llama, with the postero-internal portion of the navicular facet somewhat more extended inwardly than in the latter genus.

The Cuboid. — (Pl. IX, Fig. 5.) The cuboid is comparatively larger in the antero-posterior direction and somewhat higher than that of the camel and the llama. The calcaneal facet is long and narrow. The astragalar facet is narrow, especially posteriorly, where the calcaneum takes up the entire width of the bone, forcing the conical apex of the astragalar facet far inward, unlike that of the recent forms. The facets on the tibial side are as distinct as in the living representatives. There is a deep narrow groove immediately below the calcaneal facet on the posterior face extending clear across the bone, and differing in this respect from the llama. The posterior hook is comparatively heavy and extends outwards and downwards, fitting against the palmar process of the fourth metatarsal. The smaller portion of this bifid hook is superiorly located and is a conical projection on the tibial side with a small facet for articulation with the navicular, the distal facet supporting the fourth metatarsal is irregularly triangular in

shape with a small pit on the emarginate tibial side, similar to that of the llama.

The Navicular. — The navicular is more nearly like that of the recent Tylopoda than any bone in the tarsus. The astragalar facet is concave antero-posteriorly, with an emarginated fossa in the middle of the bone on the fibular side. On the tibial side is another smaller emargination with a small pit; and below the pit, is a small tubercle, which extends to the distal face and takes up a large portion of the tibial face of the bone. In the llama this tubercle is almost obsolete, while the camel has it better developed. The postero-inferior rounded facet for the cuboid is as prominent as in the camel and llama. Distally there are two facets, *the ecto-meso-*[17] and the ento-cuneiform, the two former are divided only by a low ridge, while the latter is separated, and placed somewhat higher on the posterior portion of the bone and is slightly convex.

The Ecto-meso-cuneiform. — The united ecto-meso-cuneiforms are comparatively much smaller, especially antero-posteriorly, than in the recent forms. Proximally two facets are indicated by a shallow groove, while the distal articulation is more continuous and more similar to that of the llama. There is only one facet for the cuboid, the antero-fibular, near the proximal end. The prominent tubercle with the rounded facet at the free end on the fibular side which abuts against the cuboid in *Camelus* is entirely absent in *O. longipes* and the llama.

The Ento-cuneiform. — The ento-cuneiform is an irregularly shaped sesamoid with a proximal, concave facet for the navicular. Near the proximal end on the anterior face is a rounded pit for articulation with the slightly projecting tubercle on the posterior face of the united ecto-meso-cuneiform.

Near the distal end posteriorly, there is a strong hook-like process with a large facet slightly convex in all directions, which articulates with the plantar process on metatarsal IV. In the llama this facet is entirely absent though the tubercle is still present in a rudimentary form. The plantar processes have become more depressed in the llama and the tubercle on the ento-cuneiform is entirely free. Distally and on the fibular side is a fourth facet for the second rudimentary metatarsal.

[17] Scott states that the ecto- and meso-cuneiforms are coalesced in *Poëbrotherium*. *Journ. Morph.*, Vol. V, No. 1, p. 42.

The Metatarsals.— One of the chief distinctive characters of *O. longipes* is the fact that the lateral metatarsals II and V are a little less reduced than is ordinarily the case in the Loup Fork camels. As in *Poëbrotherium*[18] metatarsal II has "an enlarged head" with an independent articulation, which in *O. longipes* is comparatively higher than in the llama. The bone is firmly coössified with metatarsal III and is supported by the entocuneiform. Metatarsal V, on the other hand is entirely separated proximally from metatarsal IV and articulates with that bone by a small rounded facet near the proximal end, but is not in touch with the cuboid. At the base of the palmar process of metatarsal IV, the two bones IV and V are fused leaving a peculiar ovate-shaped foramen seen in Pl. X, Fig. 4. The functional metatarsals III and IV are a trifle lighter than the metacarpals, but are of nearly the same length, thus resembling very closely the typical Tylopoda According to Prof. Scott, *Poëbrotherium* stands farther removed, having the metatarsals longer and broader than the metacarpals.

Metatarsal III is only a very little heavier than metatarsal IV, and the lateral metatarsal II, as above stated, distinctly forms a part of the functional metatarsal, as in the recent genera. Metatarsal III has two facets on the proximal end. The anterior is concave and articulates with the compound ecto-meso-cuneiform, while the posterior facet is situated on the palmar process and is a wide shallow pit for the reception of the peculiar convex facet on the ento-cuneiform. The hook-like palmar processes on metatarsals III and IV have become coössified. These are the only parts of the two bones showing any true coalescence and this is a constant character shown in all specimens of *O. longipes* in the collection of the Carnegie Museum. Metatarsal IV is lighter than metatarsal III, and they are closely applied to each other with the opposed surfaces slightly rugose and extending to within 30 mm. of these distal ends. The shafts have a slight curvature with the midshaft turned backward. Laterally the shafts are nearly straight and but little separated distally. Metatarsal IV has two proximal facets which articulate with the cuboid. The anterior articulates with the corresponding facet on the anterior half of the cuboid. The posterior is on the palmar process opposite the facet on the process of metatarsal III. On the tibial side near the anterior face is a small facet for articulation with metatarsal III. Distally, as in the meta-

[18] *Journ. Morph.*, Vol. V, Part 1, p. 42, 1891.

tarsals, the carina is comparatively strong and is confined principally to the plantar side.

Phalanges. — The proximal phalanges of the hind feet are proportionally longer than in the llama, and exhibit a repetition of the characters shown in the fore feet.

COMPARATIVE MEASUREMENTS OF THE PELVIS, HIND LIMB AND FOOT.

	O. longipes.	*C. bactrianus.*	*L. huanaco.*
Greatest length of pelvis	300 mm. [19]	420 mm.	262 mm.
Greatest width of superior border of ilium	158 mm. [19]	300 mm.	155 mm.
Length of ilium from anterior border of acetabulum to superior border	165 mm. [19]	255 mm.	168 mm.
Length of ischium from posterior border of acetabulum to ischial tuberosity	115 mm. [19]	125 mm.	105 mm.
Length of pubic symphysis	110 mm.	138 mm.	
Greatest length of femur	382 mm.	495 mm.	320 mm.
Transverse diameter of proximal end of the femur.	79 mm.	135 mm.	75 mm.
Transverse diameter of distal end of femur	67 mm.	115 mm.	63 mm.
Diameter of shaft of femur in the middle	30 mm.	45 mm.	28 mm.
Greatest length of tibia	431 mm.	440 mm.	320 mm.
Transverse diameter of proximal end of tibia	70 mm.	117 mm.	70 mm.
Greatest expansion of proximal end of tibia antero-posteriorly	84 mm.	106 mm.	67 mm.
Transverse diameter of distal end of tibia	51 mm.	85 mm.	46 mm.
Greatest length of calcaneum	115 mm.	135 mm.	85 mm.
Length of tuberosity above sustentacular facet	72 mm.	87 mm.	52 mm.
Distance from tibular facet to distal end	42 mm.	56 mm.	33 mm.
Breadth of calcaneum at sustentacular facet	37 mm.	55 mm.	30 mm.
Antero-posterior diameter of tuberosity above sustentacular facet	35 mm.	55 mm.	30 mm.
Total height of tarsus from proximal end of astragalus to distal end of cuneiform	73 mm.	108 mm.	64 mm.
Greatest height of astragalus	55 mm.	74 mm.	45 mm.
Greatest breadth of astragalus	36 mm.	50 mm.	30 mm.
Greatest height of navicular	25 mm.	17 mm.	9 mm.
Greatest height of cuneiform	14 mm.	17 mm.	10 mm.
Greatest length of metatarsals	355 mm.	347 mm.	237 mm.
Greatest length of proximal phalanx	61 mm.	88 mm.	68 mm.
Greatest length of second phalanx	33 mm.	61 mm.	35 mm.
Greatest length of ungual phalanx	28 mm.	28 mm.	20 mm.

[19] Indicates that measurements have been estimated by comparison with other individuals.

THE MOUNTED SKELETON.

Plate XV is from a drawing of the mounted skeleton. The type of *O. longipes* was used as the basis of this mount and the missing parts were substituted from other individuals of about the same size and pertaining to the same species. A few bones not represented in the collections were restored in plaster and accurate records were kept of all substituted parts. In the skeleton the restored parts are indicated by a red +, and while of the same general color as the actual bones, the shade differs sufficiently for them to be easily recognized. Each substituted bone used in the mount bears its departmental number, thus effecting a complete and permanent record as to the association of all the bones used in the construction of the composite skeleton.

The skeleton was mounted by the writer in such a manner that any bone may be readily detached from the whole.

The pose is intended to represent the animal when walking slowly on the level ground, with the head only moderately elevated.

The mounted skeleton presents many peculiarities which would be lost to the observer if seen in a disarticulated state. The small cranium, elevated above the main axis of the dorsal region, the small thoracic cavity, the narrow pelvis and the greatly elongated limbs and cervical region are characters which are fully appreciated only in the mounted skeleton. The skeleton as a whole resembles more closely that of the llama than the camel. The elevated position of the head, the curvature of the back, and the general shape of the limbs is especially like that of the llama, while the dental formula, the small and elongated cranium, the separated metapodials, the unguligrade characters of the phalanges and the extremely narrow pelvis are features readily distinguishable from either of the recent forms.

MEASUREMENTS.

Total length of skeleton from apex of premaxillary to posterior end of ischium	212 cm.
Total height from toes to top of anterior dorsal spines	130 cm.
Length of cervical region	86 cm.
Length of dorsal region	60 cm.
Length of lumbar region	48 cm.
Length of sacral region	11 cm.

Oxydactylus brachyodontus sp. nov.

The type (No. 664) (Pl. XI, Figs. 1, 2 and 3) of the above named species is represented by a fairly complete cranium with the lower jaw in position and the atlas, anterior portion of the axis and the succeeding five cervicals, the distal end of both humeri, both ulnæ and radii, the carpals, metacarpals and phalanges, the left femur, the tibia, calcaneum, astragalus, cuboid and metatarsals. There is another nearly complete skeleton (No. 562) which I have provisionally referred to this species; but unfortunately no part of the skull or lower jaw is present. The two individuals do not differ greatly in size, No. 562 being only a little larger than No. 664. The principal differences between this species and *O. longipes* are as follows:

The Cranium. — In comparison with that of *O. longipes* the cranium is relatively large. The second and third incisors are present and part of the alveolus for the first. The third incisor is smaller than the canine. The first premolar which is somewhat reduced, is subconical and has a single root. Premolars two, three and four are similar to those of *O. longipes*. The molars are brachyodont, broad and comparatively short antero-posteriorly. The outline of the skull is similar to that of *O. longipes*. The fronto-nasal suture is perhaps placed a little farther back than in the latter species.

The Mandible. — The lower jaws present characters very like those of *Protomeryx* (*Gomphotherium*) *cameloides*,[20] agreeing especially in the absence of a diastema between the incisors and canine. In *O. brachyodontus* the incisors are more reduced than in *Protomeryx cameloides*, but have the same spatulate shape. In the type of *O. brachyodontus* the teeth are much worn (Pl. XI, Fig. 4). The first premolar is fixed by two strong roots, and, as in the upper jaw, the crown is subconical with the greater diameter directed antero-posteriorly. In *Protomeryx cameloides* this tooth has a greater antero-posterior diameter and has quite distinct anterior and posterior basal tubercles. In the type *O. brachyodontus* the second, third and fourth premolars do not differ materially from those of *O. longipes*. The true molars differ from those of *O. longipes* by being proportionally broader and shorter.

The Cervicals. — (Pl. XII, Figs. 1, 2, 3 and 4.) The cervicals are comparatively short and heavy. The axis and the third cervical

[20] *Bul. Am. Mus. Nat. Hist.*, p. 118, 1898.

of No. 562 differ from those of *O. longipes*. The spines are heavier and higher than in that genus. On the axis the spine slopes forward at a greater angle and extends farther backward than does that in *O. longipes*. The length of the axis and the third cervical is more nearly equal than in *O. longipes* and the inferior keels are stronger. The fifth cervical vertebra of the type, No. 664, has a distincly higher and heavier spine (Pl. XII, Fig. 4), than the corresponding vertebra of *O. longipes*, otherwise it is similar to that of the latter species though somewhat smaller.

MEASUREMENTS OF SKULL AND VERTEBRÆ.

Length of cranium from incisor 3 to external auditory meatus	268 mm.
Total length of dental series from incisor 3 to and including molar 3	165 mm.
Distance from incisor 3 to pm. 2	64 mm.
Length of continuous molar-premolar series	93 mm.
Total length of premolars 2 to 4	37 mm.
Total length of molar series	56 mm.
Greatest length of nasals	110 mm.
Greatest length of mandible	255 mm.
Greatest height including coronoid process	138 mm.
Height of coronoid	44 mm.
Depth of ramus back of molar 3	45 mm.
Depth of ramus at diastema in front of pm. 2	22 mm.
Distance from canine to pm. 2	45 mm.
Length of continuous molar premolar series	100 mm.
Length of premolars 2 to 4	36 mm.
Length of molar series	65 mm.
Greatest length of atlas approximately	75 mm.
Greatest width of atlas approximately	75 mm.
Greatest width of cotylus	55 mm.
Greatest length of cervical 3	130 mm.
Length of centrum of cervical 3	118 mm.
Greatest length of cervical 4	126 mm.
Length of centrum of cervical 4	112 mm.
Greatest length of cervical 5	124 mm.
Length of centrum of cervical 5 approximately	100 mm.
Greatest length of cervical 6	106 mm.
Length of centrum of cervical 6	86 mm.

The Fore Limb and Foot. — (Pl. XIII.) The limbs of *O. brachyodontus* (No. 664) are elongated and rather lighter in comparison with the cranium, than in *O. longipes*. The internal epicondyle of the humerus is of greater development and the curvature of the ulno-radial shaft is more pronounced in *O. brachyodontus* than in *O. longi-*

pes. The carpal series presents no important difference from that of *O. longipes*. The metacarpals are long, slender, and distally spread more distinctly than in *O. longipes*. As in the latter species the carina is strong and located entirely on the plantar face of the bone. The phalanges have no rugose surface on their plantar sides for the attachment of pads. The unguals are high and pointed.

The Pelvis, Hind Limb and Foot.— (Pl. XIV.) The pelvic region in No. 562 is in fairly good preservation and differs but little from that of *O. longipes*. The sacrum has five, instead of four, coössified centra. The femur and tibia though smaller exhibit no important differences, which is also true of the tarsals. The metatarsals of No. 664 are damaged proximally, but No. 562, which I have associated with the type, has this region of the hind limb better preserved, and shows the coössification of the palmar processes. Metatarsal II adheres closely to metatarsal III, and metatarsal V is absent, thus approaching the llama rather than *O. longipes*.

MEASUREMENTS OF LIMBS.

Greatest width of humerus at distal end	46 mm.
Greatest height of trochlea at distal end	34 mm.
Length of radius	284 mm.
Width of radius at head	41 mm.
Width of radius medially	31 mm.
Width of radius distally	46 mm.
Length of metacarpals	255 mm.
Total length of femur, approximately	270 mm.
Total length of tibia	328 mm.
Total length of metatarsals	267 mm.
Total length of proximal phalanx	55 mm.
Total length of median phalanx	28 mm.
Total length of ungual phalanx	25 mm.

OXYDACTYLUS COMPARED WITH OTHER LOUP FORK AND LATE OLIGOCENE GENERA.

Procamelus differs from *Oxydactylus* in the absence of the first and second pairs of superior incisors, and the union of the metapodials.[21]

The genus *Piliauchenia* differs generically from *Oxydactylus* by the absence of the second inferior premolar. *Protolabis* has short limbs

[21] Some material in the American Museum of Natural History which is referred to this genus has the rugose attachment for the pads on the plantar face of the phalanges, and may have some relation to the genus *Pliauchenia*.

and neck, second superior premolar reduced, hypsodont dentition, and the metacarpals entirely separated; while *Oxydactylus* has the cervical region and limbs greatly elongated, no reduction in the dentition, brachydont teeth, metacarpals entirely separate and the metatarsals coösified only by their palmar processes. *Alticamelus* differs from *Oxydactylus* in its much greater size, by having the first and second incisors absent and the metapodials united. In *Protomeryx* (*Gomphotherium*) the limbs are comparatively much shorter than in *Oxydactylus*, the orbit is rounder and more anterior in position, the angle on the lower jaw is longer, and the metapodials are separated.

After a careful study of all the material at hand it is believed by the writer that *Oxydactylus* is most nearly allied to *Protomeryx* (*Gomphotherium*) from the John Day formation and that some form similar to *Alticamelus*[22] in the Pleistocene is the termination of this phylum. While the characters in the dentition of the latter genus, are little changed from those in *Protomeryx*, the orbit is more oblong in shape and more posterior in position. The region between the alveolar border and condyles of the skull is also comparatively shorter. The greatly elongated limbs especially in *O. longipes* contrasts strikingly with the rather short limbs in *Protomeryx*.

Alticamelus altus[23] retains some important characters similar to those in *O. longipes*, although it is much larger and more modified than the latter. The small cranium, and the structure of the neck, limbs and phalanges are suggestive of *O. longipes*.

In the Pleistocene formation are remains of camels with greatly elongated limbs[24] and these may represent the termination of this line of American fossil cameloids. This phylum appears to be divergent from that of the true camels and we are at present able to trace it with some certainty to the genus *Protomeryx* of the upper Oligocene. *Oxydactylus* presents characters resembling both the recent camels and other Loup Fork genera, but some of these are doubtless due to parallelism in development and do not signify relationship. In *O. longipes* we seem to have an animal which in some respects is even more specialized than the recent Camelidæ while in other respects it is more primitive. The elongated cervical region with the comparatively longer limbs, the metacarpals being 15 mm. and metatarsal 8 mm.

[22] *Memoirs Am. Mus. Nat. Hist.*, Vol. I, Part VII, page 422, 1901.
[23] *Memoirs Am. Mus. Nat. Hist.*, Vol. I, Part VII, p. 430, 1901.
[24] *Memoirs Am. Mus. Nat. Hist.*, Vol. X, p. 132, 1898.

longer than that of an adult specimen of *Camelus bactrianus* and the unguligrade structure of the phalanges are more specialized than those of the recent camels.[25] On the other hand the narrow and elongated cranium, the unreduced dentition, the separated metapodials and many minor characters present would be considered as primitive.

PROBABLE HABITS OF OXYDACTYLUS.

From the osteological structure of *Oxydactylus*, it would appear that specialization had been in the direction of those characters required for greater speed and endurance. The trunk became relatively lighter and the limbs stronger and more elongated than in earlier forms. The usual habitat was probably an open plain where long journeys from pasture grounds to water were necessary.

GEOLOGICAL NOTES.

Owing to the somewhat uniform character of the entire sedimentary mass of the Loup Fork series in Sioux County, Nebraska, some difficulty was met with in intelligently labeling material gathered from the different horizons. The Gering and Arickaree sandstones of Darton[26] attain a thickness of 900 to 1200 feet in this locality. For convenience and precision the writer divided the beds, temporarily, into three divisions. The *Lower Loup Fork, the Dæmonelix; and the Upper Loup Fork.* This arrangement was thought of importance in connection with the work carried on. Mr. Hatcher[27] divided the Arickaree sandstones into two distinct horizons overlaid by a third, the "Nebraska Beds" of Scott. In an ascending order the Loup Fork beds in this locality are according to Hatcher as follows:

The Gering Sandstones, consisting of some 200 feet of laminated, massive and cross-bedded sandstones.

The Monroe Creek Beds, composed of some 300 feet of very light colored, fine grained, not very hard, but firm and massive sandstones.

The Harrison Beds, composed of about 200 feet fine-grained, rather incoherent sandstones.

The Nebraska Beds, consisting of a series of buff-colored sandstones of varying degrees of hardness and unknown thickness. The Nebraska

[25] It seems to be generally accepted that the peculiar cushion foot of the Tylopoda was developed from the unguligrade condition.

[26] U. S. Geogr. S. Nineteenth Annual Report, Part IV, p. 735, 1897–98.

[27] *Proc. Am. Phil. Society*, Vol. XLI, No. 169, pp. 116–117

beds in this locality, as recently determined, can be of no greater vertical thickness than 150 to 200 feet.

The beds are exposed for four or five miles along the south side of the Running Water or Niobrara River a few miles east of the Wyoming and Nebraska State line. In the section shown in Fig. 3 the Nebraska beds have a thickness of about 70 feet. There are considerable exposures of the Nebraska beds on the south side of the Running Water River, and in places they have a vertical thickness of perhaps 200 feet.

Some fifteen miles south of the Running Water there is a series of exposures overlying the Nebraska beds. These exposures are undoubtedly the Ogalalla beds of Darton. No work was done in them by our party and their relation to the section here published is not sufficiently known to the writer to warrant any further mention.

The accompanying geological section extending from Squaw Butte on the northern face of the Pine Ridge which marks the northern limits of these beds at this locality, in an imaginary line southward for 15 miles, to the Running Water River represents the sequence of the various Loup Fork horizons in this region. The latest divisions

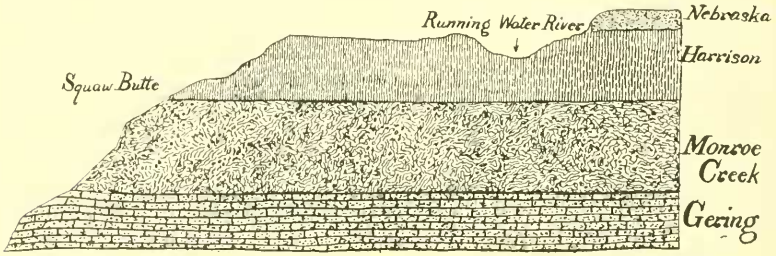

FIG. 3. Ideal section of Miocene formations from Squaw Butte to south side of Running Water River, Sioux Co., Nebraska.

and names proposed by Darton and Hatcher are used for the various horizons in the accompanying section (Fig. 3) and are believed, by the writer, to be the most satisfactory classification yet proposed of the Miocene beds in this locality. In the Gering horizon no fossil remains have been collected. The upper part of the Monroe Creek horizon has yielded some material, as has also the Harrison beds. The uppermost part of the section, or the Nebraska beds are apparently the richest in vertebrate fossils of the entire series. From this

horizon were obtained a rich and interesting collection, including the material described in the present paper.

The writer takes this opportunity of expressing his thanks to Mr. Hatcher for valuable suggestions and criticism, and to Professor Osborn for the free access given him to the various types and other material, relating to the subject, in the American Museum of Natural History in New York City.

The illustrations are from drawings made by Mr. Sydney Prentice, the draughtsman in the Section of Vertebrate Paleontology of the Carnegie Museum.

CARNEGIE MUSEUM,
October 16, 1903.

EXPLANATION OF PLATES.

PLATE IV.

Fig. 1. Side view of skull of *Oxydactylus longipes*, type (No. 918).
Fig. 2. Top view of same.
Fig. 3. Palate view of same.
Fig. 4. Mandible showing crowns of dentition.
All figures $\frac{1}{3}$ natural size.

PLATE V.

Fig. 1. Side view of atlas of *Oxydactylus longipes*, type (No. 918).
Fig. 2. Side view of axis of same.
Fig. 3. Side view of cervical 3 of same.
Fig. 4. Side view of cervical 4 of same.
Fig. 5. Side view of cervical 5 of same.
Fig. 6. Side view of cervical 6 of same.
Fig. 7. Side view of cervical 7 of same.
All figures $\frac{1}{3}$ natural size.

PLATE VI.

Fig. 1. Side view of first dorsal of *Oxydactylus longipes*, type (No. 918).
Figs. 2, 3. Side view of dorsals, 6 and 7 of same.
Fig. 4. Side view of dorsal 9 of same.
Fig. 5. Side view of dorsal 10 of same.
Figs. 6, 7. Side view of lumbars 4 and 5 of same.
Fig. 8. Inferior view of sacrum of same.
All figures $\frac{1}{3}$ natural size.

PLATE VII.

Fig. 1. External view of scapula of *Oxydactylus longipes*, type (No. 918).
Fig. 2. Front view of humerus of *Oxydactylus longipes*, cotype (No. 886).
Fig. 3. Posterior view of same.
All figures $\frac{1}{3}$ natural size.

PLATE VIII.

Fig. 1. Front view of ulna-radius and carpus of *Oxydactylus longipes*, type (No. 918). Partly restored from cotype (No. 886).

Fig. 2. Front view of right fore foot of *Oxydactylus longipes*, type (No. 918). Partly restored from the cotype (No. 886).

Fig. 3. Posterior view of right fore foot of *Oxydactylus longipes*.

Fig. 4. Front view of phalanges of *Oxydactylus longipes*, type (No. 918).

All figures $\frac{1}{3}$ natural size.

PLATE IX.

Fig. 1. Superior view of pelvis, left side of *Oxydactylus longipes*, type (No. 918).

Fig. 2. Side view of same.

Fig. 3. Tibial side of femur of same.

Fig. 4. Front view of tarsus of same.

Fig. 5. Posterior view of cuboid of same.

All figures $\frac{1}{3}$ natural size.

PLATE X.

Fig. 1. Front view of femur of *Oxydactylus longipes*, type (No. 918).

Fig. 2. Front view of tibia of same.

Fig. 3. Front view of right metatarsals and phalanges of same.

Fig. 4. Posterior view of same.

All figures $\frac{1}{3}$ natural size.

PLATE XI.

Fig. 1. Side view of skull of *Oxydactylus brachyodontus*, type (No. 664.)

Fig. 2. Top view of small skull.

Fig. 3. Palate view of small skull.

Fig. 4. Mandible showing crowns of dentition.

All figures $\frac{1}{3}$ natural size.

PLATE XII.

Fig. 1. Inferior view of atlas of *Oxydactylus brachyodontus* (No. 562).

Figs. 2, 3. Side view of cervicals 2 and 3.

Fig. 4. Side view of cervical 5, type (No. 664).

Fig. 5. Inferior view of sacrum (No. 562).

All figures $\frac{1}{3}$ natural size.

PLATE XIII.

Fig. 1. Front view of distal end of humerus of *Oxydactylus brachyodontus*, type (No. 664).

Fig. 2. Front view of ulno-radius of same.

Fig. 3. Inner view of right ulno-radius of same.

Fig. 4. Front view of metacarpals of same.

All figures $\frac{1}{3}$ natural size.

PLATE XIV.

Fig. 1. Posterior view of humerus of *Oxydactylus brachyodontus* (No. 562).

Fig. 2. Front view of same.

Fig. 3. Front view of right tibia, type (No. 664).

Fig. 4. Front view of metatarsals, type (No. 664). Proximal end restored from No. 562.

Fig. 5. Front view of phalanges, type (No. 664).

PLATE XV.

The mounted skeleton of *Oxydactylus longipes*.

About $\frac{1}{12}$ natural size.